Wisconsin Highway Research Program
Research Project Statement
FY 2008

Problem Title

Pre-overlay Repair of Existing Concrete and Asphaltic Pavements

Background and Problem Statement

A large percentage of the asphaltic paving projects performed in Wisconsin are asphaltic overlays of existing concrete or asphaltic pavements. The condition and distress of these pavements vary considerably when they are chosen for overlay, and the amount and methods of pre-overlay repairs vary widely. This lack of consistency in the pre-overlay repair leads to large variations in the performance of these asphaltic overlays. In 2004, WHRP sponsored a study, 0092-04-05, titled "Guidelines for the Surface Preparation/Rehabilitation of Existing Concrete and Asphaltic Pavements Prior to an Asphaltic Concrete Overlay." The performance of overlay using different pre-overlay repair methods was evaluated in this study. Other factors affecting the overlay performance were also investigated. Due to the budget and time limitation of previous study, the findings from previous study needs to be validated using more performance data. In addition, the cost-effectiveness of the pre-overlay repair methods needs to be determined through life cycle cost analysis before the recommendation on the amount and methods of pre-overlay repair is made.

Scope of Work/Objectives

The proposed research will result in the recommendation on the amount and method of pre-overlay repair that provides consistently good overlay performance. The project will be broken into two phases, with Phase I focused on literature review and data collection and Phase 2 will involve data analysis.

Specific Results, Findings, Tools, etc. (Deliverables)

The specific tasks for Phase 1 are as follows:

1. Review research report from the previous study 0092-04-05 and any other more recent literatures. The intent is to continue with 0092-04-05 and expand the original database.
2. Retrieve more overlay projects and obtain relevant information. The factors to be considered shall include at a minimum pre-overlay repair methods, the amount of repair in the field, overlay thickness, traffic, overlay materials, milling depth, pre-overlay pavement conditions, performance history, and maintenance history.
3. Interim report summarizing data collected and presentation of findings at a Flexible Technical Oversight Committee Meeting. The report and presentation should include a detailed work-plan for Phase 2 of the study.

Phase 2: Data Analysis includes the following specific tasks:

3. a. Determine the lives of overlays using different pre-overlay repair methods.
   b. Perform life cycle analysis and compare cost-effectiveness of per-overlay repair methods.
4. Validate findings from previous study using more overlay performance data.
5. Final Report. Document all project results and findings. Develop guidance and make recommendations on the method and amount of pre-overlay repair based on the above study.

Length of Project and Approximate Cost to Complete

It is anticipated that the literature review, data collection, data analysis, and development of guidance will be completed in two phases during a total duration of 30 months.

Phase 1 of this study will be for 20 months at a cost of $70,000. This research is dependent on actual construction techniques and project availability during construction seasons, thus the timeline for phase one has been set to include two construction seasons in hopes of providing an adequate number of projects for the expansion to 0092-04-05. Phase 2 of this study, if approved for funding will be completed in 10 months at a cost not to exceed $50,000. Award of Phase I of the project does not guarantee the award of Phase 2.

Transportation Literature Search

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Pre-Overlay Repair of Pavements

Prepared for
Wisconsin Highway Research Program
Flexible Pavements Technical Oversight Committee

January 29, 2007

Transportation Literature Searches are prepared for WisDOT staff and principal investigators to heighten awareness of completed research in areas of current interest. The citations below are representative, rather than exhaustive, of available English-language studies on the topic. Primary online resources for the literature searches are OCLC's WorldCat and TLCat, U.S. DOT's TRIS Online, the National Transportation Library (NTL), TRB's Research in Progress (RiP) and other academic, engineering and scientific databases as appropriate. Links to online copies of cited literature are noted when available. Hard copies may be obtained through the WisDOT Library at library@dot.state.wi.us or 608-264-8142.

SUMMARY
We found 10 citations that relate to the study of repairing and preparing pavements for asphaltic overlay. Of these, four were published in 2006, one in 2005, three in 2003, and two in 2000. Three were published by FHWA, one by FHWA and Ohio, two by Minnesota (though both publications pertain to the same study), and one by WHRP; the other three were found in journals and conference proceedings. We found one project in progress through late 2007 led by Nevada DOT, which considers the preparation of surfaces before overlay as a variable.

KEYWORDS
Pre-overlay, overlay, repair, preparation.

CITATIONS

Title: Investigation of pavement cracking on SR-4 and demonstration of the multi-head breaker in fracturing reinforced concrete pavements before asphalt overlay
Author(s): Arudi Rajagopal
Date: December 2006
Doc ID/URL: FHWA/OH-2006/12, Final Report.
http://www.dot.state.oh.us/research/2006/Pavements/134196-FR.pdf
Description: 65 pp.
Contents: This report presents the details of a study conducted by Infrastructure Management and Engineering (INFRAME) to review condition of selected break and seat (B/S) and rubblization projects constructed by Ohio Department of Transportation (ODOT), and also to demonstrate the ability of various pavement breakers to produce desired breaking patterns and fractured particle sizes required by ODOT specifications. A program of field evaluations was undertaken on four test projects. The pavement on SR-4 was rehabilitated in 1993 by breaking the underlying jointed reinforced concrete pavement with a pile hammer prior to constructing an asphalt overlay. The pavement on SR-36 project was rehabilitated in 1992 by rubblizing the existing jointed concrete pavement with a Resonant Pavement Breaker (RPB) and constructing an asphalt overlay. The continuous concrete pavement on I-70 was rubblized in 2005 with a Multi Head Breaker (MHB), in preparation for an initial asphalt overlay. On the I-71 project, MHB was used to demolish the existing jointed reinforced concrete pavement and demonstrate the capabilities of MHB to produce various fracturing patterns. At each test site, a test pit was dug and a visual assessment of the condition of the fractured pavement overlay and subbase/subgrade was made. Measurements were made of the fracturing pattern at the surface of the concrete and gradation tests were performed to determine the particle size distribution at various depths within the fractured slab. Deflection tests were performed to determine the effect of the observed breaking patterns on the stiffness of the pavement layers. Examination of test pit material indicated that the pile hammer used in constructing the B/S sections on the SR-4 project did not provide the vertical through cracking and steel debonding required by the project specifications. Despite this, the overlay on the B/S section provided vastly superior reflection crack performance than the untreated control section. The MHB

equipment used on I-70 appeared capable of providing the breaking patterns and particle sizes required by ODOT specifications. However, the MHB equipment used on I-71 by a different contractor did not produce the desired results; a significant amount of large, un-cracked pieces were observed particularly below the reinforcing steel, regardless of desired breaking pattern. On the other hand, the Resonant Pavement Breaker (RPB) equipment used on SR-36 produced fractured particle size distribution and steel debonding required by ODOT specifications. The principal recommendation of the study is to improve ODOT's specifications for fractured slab techniques. On all types of fracturing projects, the quality control requirements need to be modified to require that test pits be more frequently used to ensure that the specified particle size distributions are in fact being achieved throughout the depth of the slab. On rubblize projects, the present particle size distribution requirements need to be re-examined to ensure that the fracturing operation will avoid, not merely delay, reflection cracking in the subsequent overlay.

Title: Rehabilitation of Asphalt Concrete Pavements: Initial Evaluation of the SPS-5 Experiment, Final Report
Author(s): Harold L. Von Quintus, Amy L. Simpson, Ahmed A. Eltahan
Date: July 2006
Doc ID/URL: FHWA-RD-01-168. http://www.fhwa.dot.gov/pavement/pccp/pubs/01168/
Description: 209 pp.
Contents: The SPS-5 experiment, entitled "Rehabilitation of Asphalt Concrete Pavements," is one of the key experiments of the Long Term Pavement Performance (LTPP) program. The objective of this experiment is to determine the relative influence and long-term effectiveness of different rehabilitation techniques (including overlay thickness, material, and surface preparation) and site conditions (traffic, pre-existing pavement condition, and climatic factors) on performance. This report documents the first comprehensive review and evaluation of data completeness and availability from the SPS-5 experiment. Eighteen SPS-5 projects have been identified. At each site there are nine cone test sections. Some SPS-5 projects also have various supplemental sections. 210 test sections are included in the SPS-5 experiment. The data availability and completeness were good overall for the SPS-5 experiment with two exceptions: traffic and materials test data. These data deficiencies need to be addressed before a comprehensive analysis of the SPS-5 experiment is conducted. Both of these data elements must be collected in order for the SPS-5 experiment to meet the expectations for calibrating and validating mechanistic models. The majority of the SPS-5 data that were collected were at level E. Required experiment design factors were compared with the actual experiment design for the large majority of the design factors and can be characterized as good to excellent when comparing designed versus constructed. One project had yet to be constructed and materials testing and data processing still needed to be completed.

Title: Ride quality performance of asphalt concrete pavements subjected to different rehabilitation strategies
Author(s): Rohan W. Perera, Starr D. Kohn
Date: 2006
Doc ID/URL: *Proceedings of the 2006 Airfield and Highway Pavement Specialty Conference*, 2006: 789-800.
Description: 12 pp.
Contents: The Long Term Pavement Performance (LTPP) program is a 20-year study of pavement performance. The performance of asphalt concrete pavements that are subjected to different rehabilitation strategies are studied under the SPS-5 experiment in the LTPP program. In a SPS-5 project, various rehabilitation techniques are applied to eight test sections, with all of the rehabilitation techniques involving an overlay. The factors that are studied in this experiment are, overlay mix type (recycled and virgin), overlay thickness (50 and 125 mm), and surface preparation of the asphalt concrete surface prior to overlay (i.e., overlay placed with and without milling). Data obtained from SPS-5 projects were analyzed to evaluate the reduction in roughness achieved for each rehabilitation strategy, and to compare the roughness progression after rehabilitation. The International Roughness Index (IRI) was used to characterize the roughness in this study. A statistical analysis comparing the IRI of the pavement before and after the overlay indicated the IRI of the pavement after overlay did not depend on the pre-rehabilitation IRI, overlay thickness, if milling was performed or not prior to overlay, or the type of asphalt concrete used for the overlay (virgin vs. recycled asphalt). The analysis was repeated considering the SPS-5 projects that had a pre-rehabilitation IRI greater than 1.5 m/km, which only considers the rougher projects. A similar result as the previous analysis was obtained in this case too, except that milling prior to overlay was a factor that affected the IRI of the overlaid pavement. An evaluation of roughness progression over a 7-year period after the overlay was performed by using the time-sequence IRI data available for each project. The statistical analysis of data indicated the progression of roughness in the overlaid pavements depend on the pre-overlay IRI of the section and overlay thickness. The analysis did not indicate milling prior to overlay or asphalt concrete type as being significant factors that affect the progression of roughness.

Title: Study of best practices for pre-overlay repair and asphalt overlay
Author(s): Haifang Wen, Hani Titi, Darrell Berry
Date: 2006
Doc ID/URL: *Proceedings of the 2006 Airfield and Highway Pavement Specialty Conference*, 2006: 815-823.
Description: 9 pp.
Contents: Asphalt overlay on existing asphalt and concrete pavements is one of common pavement rehabilitation methods. The performance of asphalt overlay is affected by many factors and varies significantly. This study investigated the factors influencing the performance of overlay. Performance of overlays on existing asphaltic and concrete pavements was reviewed and analyzed. For asphalt overlay of existing concrete pavements, it was found that overlays using doweled concrete to patch the existing concrete pavement performed best, followed by those using non-doweled concrete patching and then asphaltic patching. The transverse cracking development rate in asphalt overlay decreases with the increase of overlay thickness. The current international roughness index (IRI) of overlay is highly correlated with initial IRI of overlay right after placement of overlay. The roughness prediction model in NCHRP 1-37A design guide was calibrated using data collected in Wisconsin. For asphalt overlay on existing asphalt pavements, the longitudinal cracking development rate decreases when the ratio of overlay thickness to milling depth increases.

Title: Guidelines for the Surface Preparation/Rehabilitation of Existing Concrete and Asphaltic Pavements Prior to an Asphaltic Concrete Overlay
Author(s): Haifang Wen, Hani Titi, Jaskaran Singh
Date: August 2005
Doc ID/URL: WHRP Project 0092-04-05, August 2005.
http://www.whrp.org/Research/publications/Final%20Reports/WHRP%2005-10%20Surface%20Preparation%20Final%20Report.pdf
Description: 93 pp.
Contents: A large percentage of the asphaltic paving projects performed in Wisconsin are asphaltic overlays of existing concrete or asphaltic pavements. Due to varying performance of overlay, a standard set of guidelines is needed to determine the amount of surface preparation which provides a consistency along with more accurate and stable project budgets for this type of work. Literature review of WisDOT and national practices of pre- overlay repair of existing concrete and asphaltic pavements was conducted. Previous asphalt overlay projects were reviewed and overlay performance was analyzed. In addition, three overlay projects during 2004 construction season were studied in the field. For asphalt overlay of existing concrete pavements, it was found that overlays with doweled concrete base patching performed best, followed by non-doweled concrete base patching and then asphaltic base patching. Partial depth repair is needed to fix the medium severity transverse cracks and longitudinal/transverse distressed joints in existing concrete pavement. A minimum of three inches, practically three and half an inch, overlay thickness was found to be able to mitigate reflective cracking in overlay. All high-severity joints/cracks/patches should be repaired. The current IRI in overlay was highly correlated with initial IRI of overlay, indicating the importance of profile index. The roughness prediction model used in the NCHRP 1-37A 2002 design guide was calibrated with locally available data. For asphalt overlay of existing asphalt pavements, block cracking in existing asphalt pavement does not adversely affect the overlay when milling is used. Existing asphalt pavement with extensive alligator cracking should be pulverized to prevent the reflection of underlying alligator cracking. Milling the existing asphalt pavement can not eliminate the reflection of transverse cracking in existing asphalt pavement. The ratio of overlay thickness to milling depth should be kept a minimum of three to prevent longitudinal cracking from re- occurring in overlay. A set of guidelines was developed to be included in the Facility Development Manual and Construction and Material Manual. Bibliography included on pp. 84-88.

Title: Analysis of influences on as-built pavement roughness in asphalt overlays
Author(s): C.M. Raymond, S.L. Tighe, R. Haas, Leo Rothenburg
Date: December 2003
Doc ID/URL: *International Journal of Pavement Engineering*, Vol. 4 (4), 2003: 181-192.
Description: 12 pp.
Contents: Pavement designers, construction engineers and contractors must understand the effects that influence the as-built roughness of a pavement so that they can maximize their designs, smoothness specifications, and bidding of contracts with smoothness specifications. This paper uses data from the Long-Term Pavement Performance (LTPP) program to examine four factors in order to determine their effects on the as-built roughness of a pavement. These factors include the extent of surface preparation prior to resurfacing, pavement roughness prior to resurfacing, overlay thickness and type of overlay material. To investigate the effects of these factors and any interactive effects, statistical procedures including paired data analyses, regression analyses and a repeated measures analysis were

performed. Results showed that the extent of surface preparation, overlay thickness, and pavement roughness prior to resurfacing had a statistically significant effect on the as-built roughness of a pavement either directly or interactively with another variable. The overlay mix type did not have an influence on as-built pavement roughness. Data from the Canadian Long-Term Pavement Performance program is used to validate the results for overlay thickness and pavement roughness prior to resurfacing. Prediction equations are also developed to estimate the as-built roughness of a pavement under various conditions. Based on these findings, it is recommended that the lower as-built roughness that is achieved by incorporating a thicker pavement overlay and/or intensive surface preparation should be considered in pavement design.

Title: Performance of rigid pavement rehabilitation treatments in the long-term pavement performance SPS-6 experiment
Author(s): K.T. Hall, C. E. Correa, A.L. Simpson
Date: 2003
Doc ID/URL: *Transportation Research Record 1823*, 2003: 64-72.
Description: 9 pp.
Contents: The results of a study conducted to assess the relative performance of different jointed rigid pavement rehabilitation treatments, including the influence of pretreatment condition and other factors, are presented. The data used in the study were drawn from the Long-Term Pavement Performance Studies' Specific Pavement Study (SPS) SPS-6 and General Pavement Study (GPS) GPS-7B experiments. The rehabilitation treatments used in the SPS-6 experiment were minimal and intensive nonoverlay repair, 4-in. asphalt overlays with minimal and intensive preoverlay preparation, 4-in. overlays with sawed and sealed joints, and 4- and 8-in. asphalt overlays of cracked and seated concrete slabs. Overall, the rigid pavement rehabilitation treatments in the SPS-6 experiment could be ranked from most to least effective in the following order: 8-in. overlay of cracked or broken and seated pavement, 4-in. overlay (of either intact or cracked or broken and seated pavement, with or without sawing and sealing of joints and with either minimal or intensive preoverlay repair), concrete pavement restoration with diamond grinding, and concrete pavement restoration without diamond grinding. Concrete pavement restoration with diamond grinding yielded an initial post-treatment international roughness index (IRI) of 1.05 m/km, on average, whereas restoration without diamond grinding yielded no benefit in IRI and in fact tended to leave the pavement rougher than before. In the long term, both restoration and overlay treatments reduced long-term roughness, rutting, and cracking levels compared with those on the control sections, but the conditions of the restored test sections are approaching those of the control sections faster than those of the overlay sections.

Title: Performance of flexible pavement rehabilitation treatments in the long-term pavement performance SPS-5 experiment
Author(s): K.T. Hall, C. E. Correa, A.L. Simpson
Date: 2003
Doc ID/URL: *Transportation Research Record 1823*, 2003: 93-101.
Description: 9 pp.
Contents: The results of a study conducted to assess the relative performance of different flexible pavement rehabilitation treatments, including the influence of pretreatment condition and other factors, are presented. The data used in the study were drawn from the Long-Term Pavement Performance Studies' Specific Pavement Study (SPS) SPS-5 and General Pavement Study (GPS) GPS-6B experiments. The rehabilitation treatments used in the SPS-5 experiment are 2- and 5-in. overlays with virgin or recycled asphalt concrete mixes with or without preoverlay milling. Overlay thickness and preoverlay roughness levels were the two factors that most influenced the performance of the asphalt overlays of asphalt pavements in the SPS-5 experiment with respect to roughness, rutting, and fatigue cracking. Over the long term, the 5-in. overlays outperformed the 2-in. overlays with respect to roughness, rutting, and fatigue cracking. Overlay mix type (virgin versus recycled) and preoverlay preparation (with or-without milling) had slight and inconsistent effects. The average initial postoverlay international roughness index of an asphalt overlay of an asphalt pavement was found to be 0.98 m/km. The data show a slight but statistically significant tendency for asphalt pavements overlaid when they were rougher to have more initial roughness after overlay than asphalt pavements overlaid when they were smoother. The data show that; on average, about 6 mm of rutting develops in the first year or so after placement of an asphalt overlay of an asphalt pavement. This is presumably due to compaction of the mix by traffic and appears to be independent of the overlay thickness, mix type, preoverlay preparation, and preoverlay rutting level.

Title: Asphalt Overlay Cost-Effectiveness: Manitoba TGS and Minnesota SPS-5 Projects 10-year Ranking of Treatments (1989-1999)
Author(s): Craig Gilbertson, Gene Skok, Dennis Watson, Tom Wilson, Benjamin Worel
Date: October 2000
Doc ID/URL: MN/RC-2000-31, Final Report. http://ntl.bts.gov/lib/11000/11500/11592/2000-31.pdf
Description: 60 pp.
Contents: This report reviews Manitoba's and Minnesota's Specific Pavement Studies (SPS-5) projects. The studies focus on investigating the performance of hot mix asphalt (HMA) overlays on HMA pavements and involve nine core test sections. The SPS-5 design variables in test sections include a control section (do nothing), amount of preparation of the existing surface (mill, no-mill), overlay thickness (50-mm, 125-mm), and the type of overlay material (virgin, recycle). Researchers plan to study the Manitoba and Minnesota SPS-5 projects, part of the Long-Term Pavement Performance (LTPP) Project, until 2010, when each project reaches the approximate age of 20 years. This project update includes a field review by the authors, a review of the existing monitoring data, and an estimate of the expected performance and cost expectations for upcoming years until 2010. Currently after 10 years all sections, excluding the control section, still are performing well. As a result at this point, researchers recommended the least costly treatment, 50-mm recycled asphalt overlay with no surface preparation, for pavement rehabilitation.

Title: Asphalt Overlay Cost-Effectiveness: Manitoba TGS and Minnesota SPS-5 Projects 10-year Ranking of Treatments (1989-1999)
Author(s): Benjamin Worel, C. Gilbertson, D. Watson, G. Skok, T. Wilson
Date: October 2000
Doc ID/URL: MN/RC-2000-31, Second Interim Report.
http://www.mrr.dot.state.mn.us/research/MnROAD_Project/MnRoadOnlineReports/2000-31.pdf
Description: 49 pp.
Contents: This report reviews Manitoba's and Minnesota's Specific Pavement Studies (SPS-5) projects. The studies focus on investigating the performance of hot mix asphalt (HMA) overlays on HMA pavements and involve nine core test sections. The SPS-5 design variables in test sections include a control section (do nothing), amount of preparation of the existing surface (mill, no-mill), overlay thickness (50-mm, 125-mm), and the type of overlay material (virgin, recycle). Researchers plan to study the Manitoba and Minnesota SPS-5 projects, part of the Long-Term Pavement Performance (LTPP) Project, until 2010, when each project reaches the approximate age of 20 years. This project update includes a field review by the authors, a review of the existing monitoring data, and an estimate of the expected performance and cost expectations for upcoming years until 2010. Currently after 10 years all sections, excluding the control section, still are performing well. As a result at this point, researchers recommended the least costly treatment, 50-mm recycled asphalt overlay with no surface preparation, for pavement rehabilitation.

RESEARCH IN PROGRESS

Title: Exploring Alternative Strategies for the Rehabilitation of Low Volume Roads in Nevada
Principal Investigator(s): Sohila Polish, Nevada Department of Transportation, 775-888-7000
Start Date: 10/1/2001
RIP URL: http://rip.trb.org/browse/dproject.asp?n=6927
Sponsor Organization: Nevada Department of Transportation
Contents: The project will explore options for replacing the current 2-inch overlay, open graded wearing course, and surface preparation rehabilitation strategies with more innovative methods of rehabilitation treatment for low volume roads. The objective of this project is to design field test sections of reliable rehabilitation treatment models using new practices of rehabilitation. Specific rehabilitation strategies to be examined and evaluated include chemical stabilization, foamed asphalt, pavement recycling technology, and utilization of milled material with rejuvenating agents. Based on the performance of the test sections, the most cost effective method(s) of alternative rehabilitation will be recommended for inclusion in NDOT's long term pavement management program.